



National Aeronautics and
Space Administration

405066-2

MSFC-SPEC-250A

October 1, 1977

Supersedes:

MSFC-SPEC-250

February 28, 1963

84

George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

PROTECTIVE FINISHES FOR SPACE VEHICLE
STRUCTURES AND ASSOCIATED FLIGHT EQUIPMENT
GENERAL SPECIFICATION FOR

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GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

PROTECTIVE FINISHES FOR SPACE VEHICLE
STRUCTURES AND ASSOCIATED FLIGHT EQUIPMENT
GENERAL SPECIFICATION FOR

1. SCOPE

1.1 Scope. - This specification describes the requirements for the protective finishes of space vehicles, structural components, and associated flight equipment. Unless otherwise specifically referred to in the end item specification, this specification does not apply to Government-furnished items or to items conforming to AN, MC, NAS, ANA and MS Standards.

1.2 Classification of protective finishes. - Levels of protective finishing shall be in accordance with one of the following classes. The contract or the detail finishing specification or both shall identify the applicable class(es) of finishing.

- Class I - Used for protection against severe corrosive environments such as exposure to sea water.
- Class II - Used for protection against moderately corrosive environments such as extended exposure to sea coast or industrial environments.
- Class III - Used for protection against mildly corrosive environments such as inland, non-industrial environments.

2. APPLICABLE DOCUMENTS

2.1 The following documents, of the issue in effect on the date of invitation for bids, form a part of this specification to the extent specified herein.

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SPECIFICATIONS

Federal

QQ-P-35	Passivation Treatments for Corrosion-Resisting Steel ¹
QQ-C-320	Chromium Plating (Electrodeposited).
QQ-N-290	Nickel Plating (Electrodeposited).
QQ-P-416	Plating, Cadmium (Electrodeposited).
QQ-S-365	Silver Plating, Electrodeposited, General Requirements for.
QQ-T-425	Tinplate, Hot Dip and Electrolytic.
QQ-Z-325	Zinc Plating (Electrodeposited).
TT-C-490	Cleaning Methods and Pretreatment of Ferrous Surfaces for Organic Coatings.
TT-E-489	Enamel, Alkyd, Gloss (for Exterior and Interior Surfaces).
TT-E-527	Enamel, Alkyd, Lusterless.
TT-E-529	Enamel, Alkyd, Semi-Gloss.
TT-P-1757	Primer Coating, Zinc Chromate, Low Moisture Sensitivity

Military

MIL-V-173	Varnish, Moisture- and Fungus-Resistant (for the Treatment of Communications, Electronic, and Associated Equipment).
MIL-F-495	Finish, Chemical, Black, for Copper Alloys.
MIL-R-3043	Resin-Coating, Permanent (for Internal Engine Parts).
MIL-M-3171	Magnesium Alloy, Processes for Corrosion Protection of.
MIL-S-5002	Surface Treatments (Except Priming and Painting) for Metal and Metal Parts in Aircraft.

MIL-B-5087	Bonding; Electrical (for Aircraft) (ASG).
MIL-E-5400	Electronic Equipment, Aircraft, General Specification for (ASG).
MIL-C-5541	Chemical Films for Aluminum and Aluminum Alloys.
MIL-C-8514	Coating Compound, Metal Pretreatment, Resin-acid.
MIL-A-8625	Anodic Coatings, for Aluminum and Aluminum Alloys.
MIL-S-8802	Sealing Compound, Temperature-resistant, Integral Fuel Tanks and Fuel Cell Cavities, High Adhesion
MIL-C-8837	Coating, Cadmium (Vacuum Deposited) (ASG).
MIL-T-10727	Tin Plating; Electrodeposited or Hot-Dipped, for Ferrous and Non-Ferrous Metals.
MIL-C-11796	Corrosion Preventative Compound, Petrolatum, Hot Application.
MIL-T-12879	Treatments, Chemical, Prepaint and Corrosion Inhibitive, for Zinc Surfaces.
MIL-F-14072	Finishes for Ground Signal Equipment.
MIL-P-14538	Plating, Black Chromium (Electrodeposited).
MIL-C-14550	Copper Plating (Electrodeposited).
MIL-P-15328	Primer, Pretreatment (Formula No. 117 for Metals).
MIL-P-15930	Primer Coating, Shipboard, Vinyl-Zinc Chromate Type (Formula No. 120 - for Hot Spray).
MIL-P-15936	Paint, Outside, Gray, No. 27 (Vinyl-Alkyd) (Formula No. 122-27).
MIL-C-16173	Corrosion Preventative Compound, Solvent Cutback, Cold-Application.
MIL-P-16232	Phosphate Coatings, Heavy, Manganese or Zinc Base (for Ferrous Metals).

MIL-E-16738	Enamel, Exterior, White, Vinyl-alkyd (Formula No. 122-82).
MIL-F-18264	Finishes: Organic, Aircraft; Application and Control of.
MIL-L-19537	Lacquer; Acrylic-Nitrocellulose, Gloss (for Aircraft Use).
MIL-L-19538	Lacquer; Acrylic-Nitrocellulose, Camouflage (for Aircraft Use).
MIL-P-20218	Chromium Plating, Electro-Deposited Porous.
MIL-C-22750	Coating, Epoxy-Polyamide, Chemical and Solvent Resistant for Weapons Systems
MIL-C-22751	Coating, Epoxy Polyamide, Chemical and Solvent Resistant, Process for Application of.
MIL-T-23142	Tape, Pressure-sensitive Adhesive, for Dissimilar Metal Separation.
MIL-P-23377	Primer Coating, Epoxy Polyamide, Chemical and Solvent Resistant
MIL-L-25681	Lubricant, Molybdenum Disulfide, Silicone
MIL-C-26074	Coating, Nickel-Phosphorous, Electroless Nickel, Requirements for.
MIL-P-26915	Primer Coating, Zinc Dust Pigmented, for Steel Surfaces.
MIL-A-40147	Aluminum Coating (Hot Dip) for Ferrous Parts
MIL-M-45202	Magnesium Alloys, Anodic Treatment of.
MIL-G-45204	Gold Plating (Electrodeposited).
MIL-R-46085	Rhodium Plating, Electrodeposited.
MIL-C-81302	Cleaning Compound, Solvent, Trichlorotrifluoroethane.
MIL-S-81733	Sealing and Coating Compound, Corrosion Inhibitive.

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STANDARDS

Military

MIL-STD-143	Specifications and Standards, Order of Precedence for the Selection of.
MIL-STD-868	Nickel Plating, Low Embrittlement, Electrodeposited.
MIL-STD-869	Flame Spraying.
MIL-STD-870	Cadmium Plating, Low Embrittlement, Electrodeposited.
MIL-STD-889	Dissimilar Metals
MIL-STD-1247	Markings, Functions and Hazard Designations of Hose, Pipe, and Tube Lines for Aircraft, Missile, and Space Systems.
MIL-STD-1501	Chromium Plating, Low Embrittlement, Electrodeposition.

(Copies of specifications, standards, drawings, and handbooks required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer).

3. REQUIREMENTS

3.1 General requirements

3.1.1 General Instructions - The application of all organic finishes prescribed herein shall be in accordance with MIL-F-18264. It shall be the responsibility of the contractor to insure that areas of a space system exposed to extreme conditions are protected by finishes that have been demonstrated to the satisfaction of the procuring activity to be suitable for the purpose. Surfaces subjected to temperatures above 250°F as a result of thermal radiation, aerodynamic heating, or other sources of heat and other surfaces that may require protection other than the standard finish, shall be protected by finishes that have been demonstrated to the satisfaction of the procuring activity to be suitable for the purpose intended. It shall be the responsibility of the contractor to establish clearly the areas affected as a result of prior experience, test information, and analysis based on mission profile and planned use of the space system.

3.1.2 Contractor's finish specification. - A specification delineating the protective finish, including cleaning and surface treatment, to be applied to the contractual articles, shall be developed by the contractor and submitted for approval to the procuring activity. When the contractor's finish specification

references manufacturer's material, process finishing specifications, and other documents, these shall be cross indexed showing their equivalency to existing Government specifications or standards for all referenced contractor-originated documents and shall be submitted with the proposed finish specification. This specification (MSFC-SPEC-250) shall be used as the basis for preparation of the finish specification which shall follow the format thereof. A detailed parts list is not required. Sufficient examples shall be listed in order that any part of the system may be properly classified as to detailed protective treatment. All parts for which the exact treatment may be in doubt and all the areas requiring special treatment shall be listed. Parts or assemblies with design features specifically noted in other specifications requiring optimum corrosion preventive treatment shall also be listed. Where alternate materials or processes are allowed herein, the contractor shall list only those alternates he intends to use. Proposed deviations from or additions to the requirements of this specification shall be identified and shall be accompanied by sufficient explanation, including test data as may be required, to permit an engineering evaluation.

3.1.3 Special finishes. - Where it is anticipated that parts may be subjected to unusual environments not described herein, the contractor shall provide adequate protective finishes for such parts, and shall describe such special finishes in the detail finishing specification. (See 3.1.1)

3.1.4 Materials and processes. - Materials and processes shall conform to applicable specifications, as specified herein. Materials and processes not covered by applicable specifications shall not be used unless approved by the procuring activity. Necessary process and quality control requirements shall be established and technical data developed which shall be submitted to the procuring activity substantiating advantages of the proposed coatings or process compared to the coating or process they are intended to replace with respect to corrosion resistance, dissimilar metal behavior, wear and other functional characteristics and effect on static and dynamic properties of the metals and alloys to which they are applied. Where a coating or process is selected for the part and the part is required to be refurbished, the coating or the coating process shall be available to the designated refurbishing activity.

3.1.5 Order of precedence. - In the case of conflict between the requirements of this specification and the detail finish specification, the latter shall prevail.

3.1.6 Selection of specifications. - The order of precedence for the selection of specifications and standards not referenced herein shall be as specified in Standard MIL-STD-143.

3.2 Cleaning requirements.

3.2.1 General cleaning requirements and precautions. - At the time of application of any finish, all surfaces shall be clean and free from dirt, grease, oil, or other contamination that may interfere with the satisfactory performance of the finish of the part. Insofar as practical, metallic surfaces shall be cleaned

as defined in MIL-S-5002 prior to application of any protective finish. The detail finish specification shall identify cleaning methods and materials to be used for the various materials of construction and, as applicable, parts with special configurations, etc., which may require special cleaning methods or materials. When the required preparatory cleaning for a particular finish is covered in the end item specification, such cleaning shall be in accordance with that specification.

3.2.1.1 Cleaning precautions. - Cleaning methods or solutions used shall not adversely affect the functioning of the part or application of the finish; e.g., do not blast clean (with large abrasive grit) close tolerance parts, light gauge parts, parts requiring very smooth surfaces, or materials susceptible to notch cracking. Where there is a significant time between cleaning and finishing or - between various finishing steps, suitable precautions to maintain cleanliness and prevent corrosion shall be observed.

3.2.1.2 Metal particles. - Fabrication and assembly procedures shall be established which preclude the retention of metal particles or pieces such as chips, slivers, rivets, bolts, tools and filings in structures for which no access exists or is afforded to the manufacturer for their removal. A vacuum cleaner providing strong suction shall be employed for frequent cleaning operations in relatively inaccessible areas. Metal cutting or filing is not permitted on an assembly after it has been accepted, except upon specific approval of the local Government representative; such areas shall be retouched in accordance with the detailed finish schedule for the part.

3.2.1.3 Use of steel wool. - The use of steel wool (either low alloy or corrosion resistant steel) is prohibited on aluminum and magnesium parts. A non-metallic abrasive shall be used or an abrasive of the same metal as discussed in 3.2.1.4.

3.2.1.4 Use of aluminum wool. - The use of aluminum wool is permitted on aluminum alloys provided precautions are taken to insure complete removal of particles from the part or assembly.

3.2.1.5 Wire brushes.

(a) Steel

The use of low alloy or carbon steel-wire brushes is prohibited on all metals except low-alloy and carbon steel.

(b) Corrosion Resistant Steel

Only corrosion resistant steel wire brushes may be used on corrosion resistant steels. On other alloys, brushing with corrosion resistant steel wire brushes is permitted provided that any given brush is restricted for use on a single basic alloy or is thoroughly acid cleaned, rinsed, and dried each time its use is changed from one basic alloy to another.

3.2.1.6 Use of other abrasive materials. - In general, aluminum and fiber wool or bristles, fine grain aluminum oxide abrasive paper, cloth or pads or other non-metallic abrasives may be used for localized cleaning provided that any given abrasive is restricted for use on a single basic alloy.

3.2.1.7 Titanium and its alloys. - Chlorinated solvents shall not be used to clean titanium surfaces with the following exceptions:

- (a) Metal surfaces which will not see elevated temperature service above 400°F may be degreased with cold chlorinated solvents provided the degreasing is followed by a hot alkaline cleaning and water rinse.
- (b) Trichlorotrifluorethane per MIL-C-81302 is not considered a chlorinated solvent for cleaning titanium.

3.3 Surface treatments. - Except as otherwise approved by the procuring activity, metals which are to receive subsequent organic finishes or which utilize the surface treatment as the only protective finish shall be surface treated as shown in the following applicable paragraphs.

3.3.1 Aluminum and its alloys. - Aluminum or aluminum alloy surfaces shall be surface treated by one or more of the following processes:

- (a) Anodize in accordance with Specification MIL-A-8625. When required, the detail finish specification shall specify type; i. e., type I (chromic acid anodize) or type II (sulfuric acid anodize). Type II is preferred for parts subject to wear, abrasion, erosion and severe corrosion conditions.
- (b) Chemical treat in accordance with Specification MIL-C-5541. Chemical conversion coated parts where subsequent organic finishing is not specified shall not be used at temperatures in excess of 150°F for corrosion resistant alloy and 130°F for non-corrosion resistant alloys (See 6.2.3).
- (c) Pretreatment coat in accordance with type III, Specification TT-C-490 and 3.1.1 may be used in lieu of treatment of (a) and (b) above when it is impractical to apply chemical or anodic treatments.
- (d) When required for an exceptionally hard surface or other special consideration, anodize per MIL-A-8625, Type III, or approved equal. These types of surface treatments are not normally used as a paint base.

CAUTION

Hardcoat treatments will reduce fatigue resistance and this effect shall be considered prior to use of these coatings on any part susceptible to fatigue failure.

3.3.2 Low alloy and carbon steel. - The surface treatments specified by the detail finish specification for low alloy and carbon steel parts shall conform

to one or more of the following.

- (a) Apply zinc phosphate treatment that conforms to type I, Specification TT-C-490 or iron phosphate treatment, that conforms to type II, Specification TT-C-490. (Used as a paint base only).
- (b) Apply pretreatment coating as specified in 3.3.1(c) (normally used as a base coating for subsequent application of additional organic coatings).
- (c) Apply manganese phosphate base that conforms to type M, Specification MIL-P-16232, or zinc phosphate base that conforms to type Z, Specification MIL-P-16232. (These treatments are not suitable as a base coating for application of subsequent organic paint coatings.)

3.3.3 Corrosion resistant steel alloys. - When subsequent organic finishes are to be applied, corrosion resistant steel shall be surface treated with a coating conforming to type III, Specification TT-C-490 and 3.1.1, or passivated in accordance with Specification QQ-P-35.

3.3.4 Magnesium alloys. - Magnesium alloy surfaces shall be surface treated by one or more of the following methods:

- (a) Treat in accordance with type III or type IV, Specification MIL-M-3171.
- (b) Apply chromate treatment per MIL-M-3171, Type VIII, or approved equal.
- (c) Anodize in accordance with Specification MIL-M-45202.
- (d) Apply MIL-M-3171, type VI dilute chromic acid treatment or approved equal (for use on parts with faying surfaces where anodic treatments are not suitable and the alloy is unsuitable for treatment in accordance with type III, Specification MIL-M-3171).
- (e) Apply pretreatment coating conforming to type III, Specification TT-C-490 (except that the acid content shall be reduced by 50 percent) over the applicable above treatment when additional organic coating shall not be applied directly over bare magnesium alloy.

3.3.5 Nickel and cobalt base alloy. - When subsequent organic finishes are to be applied, nickel and cobalt base alloys shall be surface treated with a coating conforming to type III, Specification TT-C-490, and 3.1.1.

3.3.6 Titanium and its alloys. - When subsequent organic finishes are to be applied, titanium and titanium alloy surfaces shall be treated by abrasive

blasting in accordance with method I, Specification TT-C-490, or by application of a pretreatment coating that conforms to type III, Specification TT-C-490, or both, and 3.1.1.

3.3.7 Copper and copper alloys. - Copper and copper alloy surfaces shall be surface treated by one of the following methods:

- (a) Apply pretreatment coating that conforms to type III, Specification TT-C-490 and 3.1.1 when subsequent organic coatings are to be applied.
- (b) Apply black oxide that conforms to Specification MIL-F-495. (Decorative coating only, not suitable as a paint base.)

3.3.8 Zinc surfaces. - When subsequent organic coatings are to be applied, zinc surfaces shall be treated by one or more of the methods specified below:

- (a) Apply phosphate or chromate treatments in accordance with Specification MIL-T-12879, or Specification QQ-Z-325.
- (b) Light zinc phosphate coating conforming to type I, Specification TT-C-490.
- (c) Pretreatment coating conforming to type III, Specification TT-C-490 and 3.1.1.
- (d) None (when a zinc compatible coating, such as Specification MIL-P-26915 is to be applied).

3.3.9 Cadmium surfaces. - Cadmium surfaces shall be chromate or phosphate treated in accordance with Specification QQ-P-416. When cadmium surfaces are to be painted, they may be pretreatment coated (either in lieu of or in addition to the chromate or phosphate treatment) with a coating conforming to type III, Specification TT-C-490.

3.4 Organic finish systems for interior and exterior surfaces of space vehicle structures and associated flight equipment.

3.4.1 General. - The organic-finish systems described in Table II shall be applied over the surface treatments described in 3.3.

3.4.2 Organic-finish requirements. - Except as otherwise specified herein or in the detail finishing specification, interior and exterior surfaces of flight vehicles and associated flight equipment shall be protected with organic finishes as specified in Table I. Surfaces that are to be exposed to a Class I environment shall be protected by finishes that have been demonstrated to the satisfaction of the procuring activity to be suitable for the purpose intended. It shall be the responsibility of the contractor to establish clearly the areas affected as a result of prior experience, test information, and analysis based on mission profile and planned use. Magnesium alloys shall not be used in a Class I environment.

Table I Organic-Finish Requirements 1/

Material	Protective system (see 3.4.3) and class of exposure (see 1.2)			
	Class II		Class III	
	Ext.	Int.	Ext.	Int.
Corrosion resistant aluminum and aluminum alloys <u>2/</u>	C	D	D	<u>5/</u>
Non-corrosion resistant aluminum alloys <u>2/</u>	C	D	C	D
Low alloy and carbon steel, not protected by plating or other metallic coatings <u>2/</u>	A	B or C	C	D
Corrosion resistant steels, <u>2/</u> titanium alloys, nickel and cobalt alloys and parts coated with nickel, chromium, gold, rhodium, or silver	<u>5/</u>	<u>5/</u>	<u>5/</u>	<u>5/</u>
Magnesium alloys	<u>3/</u>	<u>4/</u> or <u>3/</u>	A	B or C
Parts coated with sacrificial metals such as cadmium, zinc, or aluminum	<u>5/</u>	<u>5/</u>	<u>5/</u>	<u>5/</u>

1/ Organic-finish requirement for applicable materials not listed herein shall be determined on an individual basis by the contractor subject to approval by the procuring activity. Such finishing requirements shall be listed in the detail finishing specification.

2/ See paragraph 6.2 for definitions.

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- 3/ Apply an alkali resistant epoxy or vinyl-alkyd system as follows: Paint per Specification MIL-C-22751 or apply one coat wash primer per Specification MIL-P-15328 or MIL-C-8514, one coat primer per Specification MIL-P-15930 and one top coat per Specification MIL-E-16738.
- 4/ Apply two coats of alkali resistant epoxy conforming to Specification MIL-P-23377 or two coats of vinyl zinc chromate primer conforming to Specification MIL-P-15930. A suitable, compatible topcoat (MIL-C-22750, MIL-P-15936, or MIL-E-16738) may be used in lieu of the second coat of primer. Comparable systems providing equal or superior protection may be used when approved by the procuring activity.
- 5/ Surfaces of these materials are not normally given an organic finish for mild exposure environment; however, when required for aesthetic, color coding or protective purposes, the finishes specified shall be demonstrated to be satisfactory for the purpose intended.

3.4.3 Protective systems defined. - The protective systems outlined herein are the minimum acceptable. Contractors shall endeavor to hold to these minimums in order to prevent the addition of unnecessary weight, except in special cases where maximum corrosion resistance is desired. Definitions of all systems are as outlined in Table II Application of organic coatings shall be as specified in Specification MIL-F-18264, and 3.1.1.

Table II Organic Protective Systems

Code <u>5/</u> Designation	Primer <u>3/</u> No. of Coats <u>1/</u>	Enamel/Topcoat <u>4/</u> No. of Coats <u>1/</u>
A	1	<u>2</u> ^{2/}
B	2	<u>1</u> ^{2/}
C	1	-
D	1	-

- 1/ The word coat means a single, standard coat as defined in Specification MIL-F-18264. Dry film thickness per coat shall be as defined in 4.3 for the applicable coating material.
- 2/ Lacquers may be used in lieu of enamels when so specified in the detail finishing document provided that the number of coats is increased by one as compared to the required number of coats of enamel.

- 3/ Zinc chromate primer conforming to Specification TT-P-1757, epoxy chromate primer per MIL-P-23377, or as otherwise specified in the detail finishing specification.
- 4/ Enamel conforming to Specification TT-E-489 for gloss colors, Specification TT-E-529 for semi-gloss colors, or Specification TT-E-527 for lusterless colors, epoxy topcoat specification MIL-C-22750, or as otherwise specified in the detail finishing specification.
- 5/ See Table I for definition of codes.

3.5 Inorganic protective finishes.

3.5.1 General. - Inorganic finishes shall be used as required for protection, or to provide special surfaces not otherwise as readily or economically obtainable. Small low alloy steel parts should be plated. Other materials may be plated or coated with other inorganic finishes to obtain a different surface hardness, to improve corrosion resistance, to change galvanic potential, to improve electrical contact, to change heat transfer properties, or to change appearance. Prior to the application of any inorganic finish, the surfaces to be finished shall be chemically clean, as defined in 3.2.1, or when preparatory cleaning is covered by the applicable coating specification, cleaning shall be in accordance with that specification. Except as otherwise approved by the procuring activity, all inorganic finishing shall be in accordance with the applicable requirements herein.

3.5.2 Plated metallic finishes. - Prior to the application of any plating, the basis metal shall be free of flaws or defects that will be detrimental to the performance or appearance of the applied plating.

3.5.2.1 Cadmium plating. - Cadmium plating shall conform to Specification QQ-P-416. Type II, class 2 shall be the preferred protective plating method for general applications. Type II, class 3 should be used for close tolerance parts, except that Type I, class 3 should be used on close tolerance threaded parts when a minimum torquing resistance is required. The usage of cadmium plating shall be subject to the following restrictions:

- (a) Cadmium plating shall not be used for any application where the plated surfaces will be exposed to a temperature of 450°F or greater.
- (b) Cadmium plating shall not be used where a hard or highly abrasion resistant surface is required.
- (c) Cadmium plating shall not be used for parts of hydraulic equipment which may be in contact with hydraulic fluids and fuels.
- (d) Cadmium is corroded by vapors of some organic materials and should not be used in confined areas where prolonged exposure to organic materials is possible.

- (e) Cadmium plating shall not be used in applications where a hard vacuum is expected.
- (f) Cadmium plating shall not be used on titanium or parts that will be in direct contact with titanium.
- (g) When cadmium is plated on steel heat treated from 160,000 to 180,000 pounds per square inch (psi) (Rockwell C-35 to C-40) the plated part shall be baked at 375 (plus or minus 25) degrees F for a minimum of 3 hours. Cadmium plating on steel heat treated from 180,000 to 220,000 psi (Rockwell C-40 to C-48) shall be baked at 375 (plus or minus 25) degrees F for a minimum of 23 hours.
- (h) For cadmium plating of steel exceeding 220,000 psi (Rockwell C-40) use vapor plating process conforming to Specification MIL-C-8837 or electroplating in accordance with Standard MIL-STD-870 when approved by procuring activity.

3.5.2.2 Nickel plating. - Nickel plating shall conform to Specification QQ-N-290 (electrodeposited) or Specification MIL-C-26074 (electroless). Nickel plating should be used when the plated surfaces may be subjected to temperatures up to 1,000°F, or when a highly corrosion resistant surface is required. Electroless nickel is particularly adaptable on irregularly shaped parts when a uniform thickness plate is required. When a very hard nickel plating (up to Rockwell C-38) is required, type II, Specification MIL-C-26074 (heat treated) electroless nickel should be specified. Except as otherwise approved by the procuring activity, the following minimum thickness of nickel plating shall be applied when the plating is to provide protection from corrosion.

- (a) Surfaces with roughness-height-rating (rhr) not greater than 32 rhr - 0.001 inch thick (minimum).
- (b) Surfaces rougher than 32 rhr but not rougher than 125 rhr - 0.0015 inch (minimum).
- (c) If it is considered necessary to plate surfaces exceeding 125 rhr, special precautions shall be taken to insure that the plating is free of voids or porosity that will reduce the protective effectiveness of the plating. When nickel is plated on steel heat treated from 160,000 to 180,000 psi (Rockwell C-35 to C-40), the plated part shall be baked at 375 \pm 25 degrees F for a minimum of 3 hours. Nickel plating on steel heat treated to 180,000 psi or above shall conform to the requirements of MIL-STD-868.

3.5.2.3 Chromium plating. - Chromium plating shall conform to Specification QQ-C-320. Chromium plating should be used where plated surfaces are exposed to temperatures up to 1,000°F, or where a hard, wear, or abrasion resistant, low friction surface is required. When the plating must provide protection from corrosion, minimum thickness of the plating shall be 0.002 inch. When chromium is plated on steel heat treated from 160,000 to 180,000 psi the plated parts shall be baked at 375 \pm 25 degrees F for a minimum of 3 hours. High strength steel parts heat treated to 180,000 psi and above shall be in conformance with MIL-STD-1501. Porous chromium plating, conforming to Specification MIL-P-20218, or black chromium plating, conforming to Specification MIL-P-14538 (ORD), may be used when required for special applications.

3.5.2.4 Copper plating. - Copper plating shall be used only as a base for other platings or to provide good electrical conductivity. Where copper plating is specified the plating shall conform to the requirements of Specification MIL-C-14550.

3.5.2.5 Silver plating. - Silver plating shall be used only when special surface effects are required, such as good electrical conductivity or high seizure resistance. When silver plating is specified it shall conform to the requirements of Specification QQ-S-365.

3.5.2.6 Tin plating. - Tin plating shall be used only when its use presents distinct advantages for the purpose intended; for example, to improve solderability. When tin plating is specified it shall conform to the requirements of Specification MIL-T-10727.

3.5.2.7 Gold plating. - Gold plating shall be used only when its special properties are required, such as corrosion resistance. When gold plating is specified the plating shall conform to the requirements of Specification MIL-C-45204.

3.5.2.8 Rhodium plating. - Rhodium plating shall be used only when its particular properties are required, such as hardness and wear resistance, low electrical resistance, and resistance to corrosion. Where rhodium plating is required, the plating shall conform to the requirements of Specification MIL-R-46085.

3.5.3 Miscellaneous inorganic finishes. -

3.5.3.1 Hot dipped metallic coatings. - Hot dipped metallic coatings may be used in lieu of electroplating when specifically approved by the procuring activity. When the use of hot dipped metallic coatings is authorized the coatings shall conform to the following specifications:

- (a) Tin coatings - Type II, MIL-T-10727 or QQ-T-425.
- (b) Aluminum - MIL-A-40147.

Restrictions noted in 3.5.2, for the applicable metal, shall apply for hot-dip coatings.

3.5.3.2 Sprayed metal coatings. - When sprayed metal coatings are specified, application shall conform to the requirements of Standard MIL-STD-869.

3.5.3.3 Porcelain enamels and ceramic coatings. - Porcelain enamels or ceramic coatings shall only be used when their high temperature stability or other special properties are required. When porcelain enamels or ceramic coatings are specified, they shall be applied by methods approved by the procuring activity.

3.6 Special finishing requirements.

3.6.1 General. - When any preceding requirement is in conflict with the requirements of this section, the requirements of this section shall prevail.

3.6.1.1 Cut edges. - The edges of all metals in exterior locations shall be rounded to permit adhesion of an adequate thickness of subsequently applied paint coatings or sealant (as applicable), since this is not obtainable over sharp edges. After rounding of edges, and prior to the application of paint, applicable chemical surface treatments shall be applied.

3.6.1.2 Drainage. - Drain holes shall be provided to prevent collection and/or entrapment of rain, sea water or other unwanted fluids which can enter by various methods. All designs shall include considerations for the prevention of water or fluid entrapment and insure that drain holes are located for maximum drainage of accumulated fluids.

3.6.2 Faying surfaces, joints, and seams.

3.6.2.1 Similar metals. - All seams or joints formed by compatible metals, as defined by Table III or MIL-STD-889 shall be protected by applying to each surface the same number of coats of primer as prescribed for interior surfaces by Table I; i.e., apply primer as required for the applicable metal. Exceptions to the foregoing are as follows:

- (a) Welded joints, at the time they are welded, shall be free of organic materials other than approved "weld-through" type primers.
- (b) Faying surfaces that are to be adhesively bonded shall be surface treated and processed as specified in the approved bonding procedures as prescribed for the assemblies concerned.

- (c) When Class I protection is required, faying surfaces of all metal alloys shall, in addition to the required primer, be sealed by applying sealing compound conforming to MIL-S-8802 or MIL-S-81733 or other approved sealant to both faying surfaces and assembling the joint while the sealant is still wet so that sealant is squeezed out at all boundaries. Remove excess material except that required to form a fillet extending approximately 1/4-inch beyond and completely around the joint boundary. Butt joints shall be sealed in a similar manner and; in addition, the seams should be grooved with a 1/8-inch minimum width groove and filled with sealant.

3.6.2.2 Dissimilar metal couples. - Except as prescribed in 3.6.3 through 3.6.17 each metal of dissimilar metal couples, as defined by Table III or MIL-STD-889 shall be primed as prescribed for interior surfaces for the applicable metal (see Table I), except that each contacting dissimilar metal surface shall be coated with at least one coat of primer. For structural application, aluminum connected to stainless steel or any alloys more noble than stainless steel should be separated with tape meeting the requirements of MIL-T-23142 or sealing compound [see (b) below]. In addition, the following requirements shall apply:

- (a) When magnesium will be in faying surface contact with corrosion resistant steel, or other metals in groups 1 through 5 in Table III, and the couple will be subjected to class II or class III environments, apply a vinyl tape or comparable material to separate the two metals. The tape shall completely cover the faying surface and whenever practical shall extend at least 1/4-inch beyond the joint area.
- (b) For class I environments, seal all dissimilar metal faying surfaces by applying an approved sealing compound conforming to Specification MIL-S-8802 or MIL-S-81733 to one of the faying surfaces and assembling the joint while the sealant is still wet so that sealant is squeezed out at all boundaries. Remove excess material except that required to form a fillet extending approximately 1/4-inch beyond and completely around the joint boundary.
- (c) Butt joints of dissimilar metals shall receive protection equivalent to that specified above. Where sealing of the joint is required, the seam may be grooved with a 1/8-inch (minimum width) groove that will be subsequently filled with an approved sealant.
- (d) When desired organic adhesive barrier tapes or primed metal shims (using a metal which is galvanically intermediate between the two dissimilar metals) may be used in lieu of additional primer coats.

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Table III. Compatible couples

Group No.	Metallurgical category <u>3/</u>	Compatible couples <u>1/</u>
1	Gold, solid and plated; gold-platinum alloys; wrought platinum	○
2	Rhodium plated on silver-plated copper	● ○
3	Silver, solid or plated; high silver alloys	● ● ● ○
4	Nickel, solid or plated; monel metal, high nickel-copper alloys, titanium	● ● ● ○
5	Austenitic stainless steels; copper, solid or plated; low brasses or bronzes; silver solder; German silver; high copper-nickel alloys; nickel-chromium alloys	● ● ● ● ○
6	Commercial yellow brasses and bronzes	● ● ● ● ○
7	High brasses and bronzes; naval brass; muntz metal	● ● ● ● ○
8	18% chromium type steels	● ● ● ● ○
9	Chromium, plated; tin, plated; 12% chromium type steels	● ● ● ● ○
10	Tin-plate;terneplate; tin-lead solders	● ● ● ● ○
11	Lead, solid or plated; high lead alloys	● ● ● ● ○
12	Aluminum, wrought alloys of the Duralumin type	● ● ● ● ○
13	Iron, wrought, gray, or malleable; plain carbon and low alloy steels, armco iron	○ ● ● ● ●
14	Aluminum, wrought alloys other than Duralumin type; aluminum cast alloys of the dilicon type	● ○ ● ● ●
15	Aluminum, cast alloys other than silicon type; cadium, plated and chromated	● ● ● ○ ● ●
16	Hot-dip-zinc plate; galvanized steel	● ○
17	Zinc, wrought; zinc-base die-casting alloys; zinc, plated	●
18	Magnesium and magnesium-base alloys cast or wrought	● <u>2/</u>

NOTE

Plating should be used to avoid or alleviate dissimilar metal couples whenever practical. For example, a corrosion resistant steel-aluminum dissimilar metal couple may be avoided by cadmium plating the corrosion resistant steel.

- 1/ Members of groups connected by lines will form permissible couples. O indicates the most cathodic member of the series, ● an anodic member, and the arrows the anodic direction.
- 2/ Aluminum alloys 5052, 5056, 5356, 6061, and 6063 are considered to be compatible with magnesium alloys.
- 3/ A more detailed listing of metals in each group is given in Specification MIL-F-14072.

3.6.2.3 Slip or press fits. - Slip fits shall be assembled using wet zinc-chromate primer, wet epoxy primer or wet MIL-S-8802 or MIL-S-81733 sealant. If design requires disassembly, the primer shall be applied and permitted to dry thoroughly before assembly. Where these materials are not compatible with the function of the part, preservative compound conforming to MIL-C-16173, Grade 1 or Grade 2, shall be used. Parts permanently housed in grease or oil shall be assembled with the grease or oil to be used in the housing.

3.6.3 Surfaces exposed to reactive materials. - Surfaces that will be exposed to reactive materials, such as liquid oxygen, shall not be finished with material that may present a reactive hazard or that may be detrimental to reactive material involved. In such cases, materials of construction should be as corrosion resistant as practical and finishes shall be limited to those that are compatible with the reactive materials contained. Finishes to be used on such surfaces shall be specified in the detail finishing specification.

3.6.4 Functional surface. - Finishing of functional surfaces shall be limited to finishes that will not be detrimental to the intended function of the surface or part.

3.6.5 Thermal control finishes or surfaces. - When controlled thermal emissivity, reflectivity, absorptivity, or insulative surfaces or coatings, or any combination of the aforementioned are required, the detail finishing specification shall define the finishes required.

3.6.6 Closely coiled springs. - Springs that are closely coiled, preventing the application of plating to internal surfaces, shall receive class C protection as specified in Table II or shall be coated with material conforming to class 2, Specification MIL-C-11796, or grade 2, Specification MIL-C-16173.

3.6.7 Parts housed in or permanently coated with oil or grease. - Parts housed in or permanently coated with lubricating oil, hydraulic oil, or grease shall not be painted except that a baked resin coating conforming to Specification MIL-R-3043 may be applied to those parts that will be in contact with lubricating oil or grease.

3.6.8 Surfaces subjected to high temperatures. - Painted surfaces subjected to temperatures up to 250°F (and up to 350°F for short durations) shall be finished as required by Table I. Surfaces that are exposed continuously to temperatures above 250°F and any exposure above 350°F shall be protected by finishes that have been demonstrated to the satisfaction of the procuring activity to be suitable for the purpose intended.

3.6.9 Tubing.

3.6.9.1 Plumbing lines. - Paint coatings shall not be allowed on the interior surfaces of tubing or other plumbing lines. When paint coatings are specified on exterior surfaces of hydraulic or other contamination sensitive fluid lines, such paint coatings shall be omitted for a distance of one inch, minimum, from each fitting.

3.6.9.2 Steel tubing. - The interior of structural steel tubing shall be coated with an inhibited primer or corrosion preventative compound conforming to specification MIL-C-11796 or Specification MIL-C-16173.

3.6.9.3 Aluminum alloy tubing. - Interior surfaces of structural aluminum-alloy tubing not closed by welding shall be coated with a chromate primer.

3.6.10 Fasteners and associated parts.

3.6.10.1 General finish. - Prior to installation and except as otherwise provided, fasteners and associated parts such as rivets, screws, bolts, washers, nuts, clamps, etc., shall be finished as follows:

- (a) Aluminum alloy parts shall be anodized in accordance with Specification MIL-A-8625.
- (b) Low alloy steel parts shall be plated, subject to the restrictions noted for the applicable plating in 3.5.
- (c) Corrosion resistant steel, titanium, or other corrosion resistant fasteners should be plated when such plating will avoid or alleviate dissimilar metal couples.

Fasteners need not be painted prior to installation except when dissimilar metal or wood contact is involved. In such cases, the fasteners shall be coated with primer or approved sealing compounds and installed while still wet or for removable or adjustable fasteners, install with corrosion preventative compound conforming to Specification MIL-C-11796 or MIL-S-16173. Insofar as practical, in all cases where a dissimilar metal contact with the fastener cannot be avoided, the fastener shall be selected so as to be the cathodic (most noble) member of

the couple. Faying surfaces should be sealed, if possible. (See 3.6.2). Polysulfide sealants, such as MIL-S-8802, MIL-S-81733, provide good corrosion resistance. When fasteners and associated parts are to be exposed to a class I environment, the installation must include protective and sealing materials to prevent the entry of sea water. These materials shall be the same materials as those utilized for sealing the faying surfaces (see 3.6.2). Sealants shall be applied to both the fastener and fastener hole and assembled while wet so that sealant fills all voids and is squeezed out at all boundaries. In addition, both exposed ends of the fastener (such as bolt head and nut) shall be over-sealed to completely encapsulate the entire fastener in sealant.

3.6.10.2 Adjustable parts. - Threads of adjustable parts, such as tie rods, turnbuckles, etc., shall be lubricated and protected before and after assembly with lubricant conforming to Specification MIL-L-25681 or equivalent, or protected with corrosion-preventative compound conforming to Specification MIL-C-16173 or Specification MIL-C-11796.

3.6.10.3 Washers. - Aluminum-alloy, 5356, washers of suitable design shall be used under machine screws, countersunk fasteners, bolt threads, and nuts that would otherwise be in dissimilar metal contact with magnesium.

3.6.10.4 Touchup. - Insofar as practical all attaching parts shall be touched up after installation in accordance with the requirements of Table I. Top coats shall be applied over the primer as required to match surrounding areas.

3.6.11 Areas Subjected to corrosive fluid. - Surfaces within 12 inches of storage batteries and any surfaces further removed that may be subject to spillage or spray from batteries and other areas subjected to corrosive fluids shall be finished with one coat of pretreatment primer, type III, Specification TT-C-490, plus one coat of vinyl primer conforming to Specification MIL-P-15930 plus two coats of vinyl topcoat conforming to Specification MIL-P-15936 or finished in accordance with MIL-C-22751.

3.6.12 Resistance to synthetic lubricants. - Interior and exterior surfaces that require an organic finish and are subject to the influence of synthetic lubricants shall be finished with a lacquer conforming to the requirements of Specification MIL-L-19537, or Specification MIL-L-19538, MIL-C-22750 or other such finishes as may be approved by the procuring activity.

3.6.13 Electrical bonding and grounding. - All faying surfaces of electrical bonding connections shall be free of non-conducting coatings or materials. Paint and anodic films on aluminum or magnesium parts shall be removed. Light films conforming to Specification MIL-C-5541 on aluminum need not be removed provided a resistance of up to 20,000 microhms is permissible. Any areas of

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finish, adjacent to the bond, that have been damaged or removed shall be re-applied. For magnesium alloy parts repriming of damaged areas shall be accomplished within 24 hours after removal of the protective finish. Dissimilar metal contacts requiring electrical conductivity shall be arranged in accordance with Specification MIL-B-5087. Protective coatings and materials for areas subject to exposure in a class I environment shall be demonstrated to be satisfactory for the purpose intended.

NOTE

This paragraph is not intended to apply to radio frequency (R-F) bonding. Where R-F bonding is required and dictates inadequate protective finishes in the bond area, each such application shall be approved by the procuring activity.

3.6.14 Surfaces of components exposed to exceptionally corrosive environments. - When it is anticipated that components will be subjected to exceptionally severe or unusual corrosive conditions, the detail finish specification shall provide additional or improved finishes as necessary to provide adequate protection. (see 3.1.1)

3.6.15 Molded plastics and ceramics. - Plastic parts need not be painted except as required for color matching.

WARNING

Under no circumstances shall plastic or ceramic insulators for antennae, etc., be painted.

3.6.16 Rubber. - Natural and synthetic rubber shall not be painted, greased, or oiled. Small rubber parts that are already installed need not be masked to prevent minor over-spray.

3.6.17 Mildew or fungus. - Surfaces subject to objectionable effects from mildew or fungus shall be protected by a coating of varnish that conforms to Specification MIL-V-173, or another quality effective treatment approved by the procuring activity.

3.6.18 Colors, insignia, and markings.

3.6.18.1 General. - The exterior and interior colors, insignia, and markings of space vehicles shall be as specified by the procuring activity in the contract or order, or as approved by the procuring activity.

3.6.18.2 Fluid lines. - Fluid lines shall be color coded in accordance with MIL-STD-1247.

3.7 Workmanship. - When an item is delivered to the procuring activity, the protective finishes shall be in accordance with the detail finish specification and shall be satisfactory and suitable for service except as otherwise approved by the procuring activity.

4. QUALITY ASSURANCE PROVISIONS

4.1 General. - When inspection is conducted at the contractor's plant, all inspections and tests shall be conducted by the contractor under the surveillance of the Government inspector.

4.2 Inspection tests. - All surface preparations, coatings and finishes shall be inspected to insure compliance with the requirements of this specification, or the finishing specification, as applicable. MIL-F-18264 and MIL-S-5002 shall be used as guidelines for all inspections.

4.3 Coating Thickness. - The coating thicknesses shall apply for a minimum of 80 percent of the reasonable flat area coated on any part, assembly, or item which may be selected for coating thickness inspection. Some variation of coating thickness, outside the above range, must be expected in corners, recesses and other difficult-to-paint areas. However, such variations shall be held to a minimum.

4.4 Previous approval. - Acceptance or approval of material during the course of manufacture or procuring activity approval of finish schemes shall not be construed as a guarantee of the acceptance of the finished product.

4.5 Rejection and retest. - Protective finishes not conforming to the requirements of this specification, or the detail finish specification, as applicable, shall be subject to rejection at the option of the procuring activity. Rejected finishes may be reworked or replaced to correct the defects and resubmitted for acceptance. Full particulars concerning any previous rejection and the action taken to correct the defects found in the original shall be furnished to the Government inspector either at the time of resubmission or prior to resubmission.

5. PREPARATION FOR DELIVERY

(Not applicable)

6. NOTES

6.1 Intended use. - This specification is intended to give the general requirements applicable to the cleaning, surface treatment and finishing of space vehicles and associated flight equipment. It is considered that this specification allows a maximum of options and it is intended that the detail finishing specification shall identify, from among these options, those materials, processes, etc., that the contractor will use.

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6.2 Definitions.

6.2.1 Interior and exterior surfaces. - Any surface which, during normal service life of the item involved, customarily forms an exterior surface of the equipment in its assembled condition; such that on outdoor exposure of the equipment the surface might be exposed to direct action of the elements (sunlight, rain, sand, dust, etc.), will be considered to be an exterior surface. All other surfaces will be considered as interior surfaces. (Materials or parts inside a hermetically sealed enclosure do not require surface protection; however, if protection is used, it shall be in accordance with the applicable requirements of this specification.) In the case of large assemblies, such as one stage of a multi-stage space vehicle, which may spend a major portion of their service life as end items subject to transportation, outdoor exposure, etc., determination of interior and exterior surfaces will be based on the configuration of the "Large Assembly."

6.2.2 Corrosion resistant and non-corrosion resistant aluminum alloys. - "Corrosion resistant aluminum alloys" include aluminum alloys 1100, 3003, 5052, 5056, 5086, 5356, 5456, 6053, 6061, and all clad alloys. All other aluminum alloys will be considered to be "non-corrosion resistant aluminum alloys."

6.2.3 Corrosion resistant and non-corrosion resistant (low alloy) steel. - Steels having 12 percent or more effective chromium will be considered to be corrosion resistant steels. Steels having less than 12 percent effective chromium will be considered to be non-corrosion resistant steels.

NOTE

Effective chromium equals total percent chromium minus (11 times percent carbon).

6.2.4 Changes from previous issue. - The outside margins of this document have been marked with a black line | to indicate where changes (deletions, additions, etc.) from the previous issue have been made. This has been done as a convenience only and the Government assumes no liability whatsoever for any inaccuracies in these notations. Bidders and contractors are cautioned to evaluate the requirements of this document based on the entire content as written irrespective of the marginal notations and relationship to the last previous issue.

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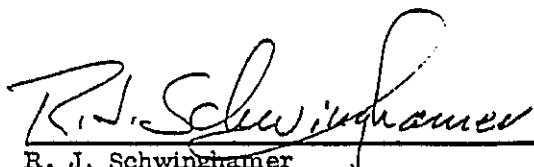
National Aeronautics and
Space Administration

Preparing activity:

George C. Marshall Space
Flight Center

Specification: Welding, Aluminum Alloys

Approved by:



R. J. Schwinghamer
Director
Materials and Processes Laboratory

MSFC DOCUMENTATION REPOSITORY - DOCUMENT INPUT RECORD

I. GENERAL INFORMATION

1. APPROVED PROJECT:	2. DOCUMENT/ DRAWING NUMBER: <i>SPEC</i> MSFC-STD-250	3. CONTROL NUMBER:	4. RELEASE DATE: 09/28/1977	5. SUBMITTAL DATE:
6. DOCUMENT/DRAWING TITLE: Protective Finishes for Space Vehicle Structures and Associated Flight Equipment, General Specification for			7. REPORT TYPE:	
8. CONTRACT NUMBER / PERFORMING ACTIVITY:	9. DRD NUMBER:	10. DPD / DRL / IDRD NUMBER:		
11. DISPOSITION AUTHORITY (Check One) <input checked="" type="checkbox"/> Official Record - NRRS <i>8/12/19</i> <input checked="" type="checkbox"/> Reference Copy - NRRS 8/5/A/3 (destroy when no longer needed)	12. SUBMITTAL AUTHORITY:	13. RELEASING AUTHORITY: <i>M. B. Cook</i>		
14. SPECIAL INSTRUCTIONS:				
15. CONTRACTOR/SUBMITTING ORGANIZATION, ADDRESS AND PHONE NUMBER:		16. ORIGINATING NASA CENTER:		
		17. OFFICE OF PRIMARY RESPONSIBILITY:		
18. PROGRAMMATIC CODE (5 DIGITS):			19. NUMBER OF PAGES:	

II. ENGINEERING DRAWINGS

20. REVISION:	21. ENGINEERING ORDER:	22. PARTS LIST:	23. CCBD:

III. REPORTS, SPECIFICATIONS, ETC.

24. REVISION:	25. CHANGE:	26. VOLUME:	27. BOOK:	28. PART:	29. SECTION:
30. ISSUE:	31. ANNEX:	32. SCN:	33. DCN:	34. AMENDMENT:	
35. APPENDIX:	36. ADDENDUM:	37. CCBD:	38. CODE ID:	39. IRN:	

IV. EXPORT AND DISTRIBUTION RESTRICTIONS

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40. ORG. CODE: <i>ED33</i>	41. PHONE NUMBER: <i>4-2701</i>	42. NAME: <i>Chip Jones</i>	43. SIGNATURE/DATE: <i>W. R. Lammell for</i> <i>10/15/03</i>
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VI. TO BE COMPLETED BY MSFC DOCUMENTATION REPOSITORY

44. RECEIVED BY: <i>Sammy Wise</i>	45. DATE RECEIVED: <i>10-22-03</i>	46. WORK ORDER:
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